

THE WEATHER AND CIRCULATION OF JULY 1957¹

Drought in the East

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1. MONTHLY CIRCULATION AND ITS CHANGE FROM JUNE TO JULY

The most impressive single aspect of the mean circulation for July 1957 was its complete reversal in phase from the previous month. From Japan eastward through Europe there occurred a shift in the westerly wave train equivalent to a phase change of about 180°. Although the definite establishment of this new regime coincided with the transformation of hurricane Audrey into a major perturbation in the westerlies, the need for shortening of the wave length as the westerlies weakened and shifted northward had been quite evident during latter June.

The preceding article in this series [1] examined in considerable detail the June circulation (fig. 1) and described the initiation of the new circulation regime which occurred near the end of that month. Figure 2, the mean 700-mb. pattern for July, shows a typically summer circulation with a trough off either coast, a ridge over the Great Plains, and an upper level anticyclone near the center of the United States. Comparison with June (fig. 1) reveals the striking change between the two months; i. e., the westerly troughs of June were replaced by ridges in July, and the ridges of June were replaced by troughs. In addition, there was, in effect, an increase in the mean wave number from five to six. In the average, normal seasonal trends may be accompanied by a similar increase, but the changes are seldom accompanied by so nearly a complete opposition in phase.

Since local weather can, in general, be associated with the abnormalities in the 700-mb. mean patterns, it is profitable to compare the departures from normal in June, figure 1, with those of July, figure 2. The overall contrast is quite impressive, even in many areas far removed from the main belt of westerlies. When we used the data at 50° N. latitude as roughly representative of the westerly belt, the linear correlation coefficient between the 700-mb. height anomalies of June and those of July at 36 points 10° longitude apart was found to be -0.61 . Thus it becomes obvious that not only did the phase of the circulation change, but so also did the anomalous features or flows.

Another way of illustrating this aspect is presented in figure 3 which shows the change in 700-mb. height anomalies (seasonal trend thus excluded) from June to July. In almost every case rises show where troughs and below

normal heights (June) were transformed to ridges of above normal height (July), and vice versa. Monthly oscillations—or reversals in circulation characteristics—have been noted quite frequently in previous articles of this series [2, 3, 4, 5, 6]. However, July is usually more apt to reflect persistence of the June regime than a sharp reversal [7].

Aside from these rather unusual changes in local circulation characteristics, the monthly pattern also reflects a continuation of blocking activity. It is tempting to relate the general prevalence of blocking in the last several years to the rise and continued high level of sunspot activity, but conclusive statistical proof of the association has not yet been forthcoming. During July (fig. 2) the most conspicuous area of such action was over the Bering Sea, where heights were 340 feet above normal and sea level pressures (Chart XI, inset) some 7 mb. higher than normal. Also affected were the Greenland area and north-central Siberia. In fact, above normal heights and sea level pressures extended from Hudson Bay eastward (at 65° N.) all the way through northern Asia to Alaska—an almost

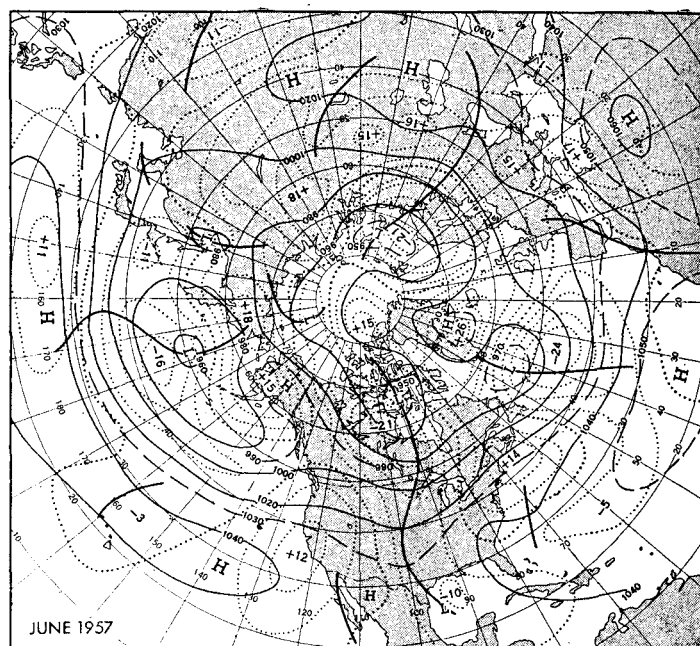


FIGURE 1.—Mean 700-mb. contours (solid) and height departures from monthly normal (dotted) (both in tens of feet) for June 1957. Dominant feature in the United States was the mean trough (heavy vertical line) through central part of country.

¹ See Charts I-XVII following p. 268 for analyzed climatological data for the month.

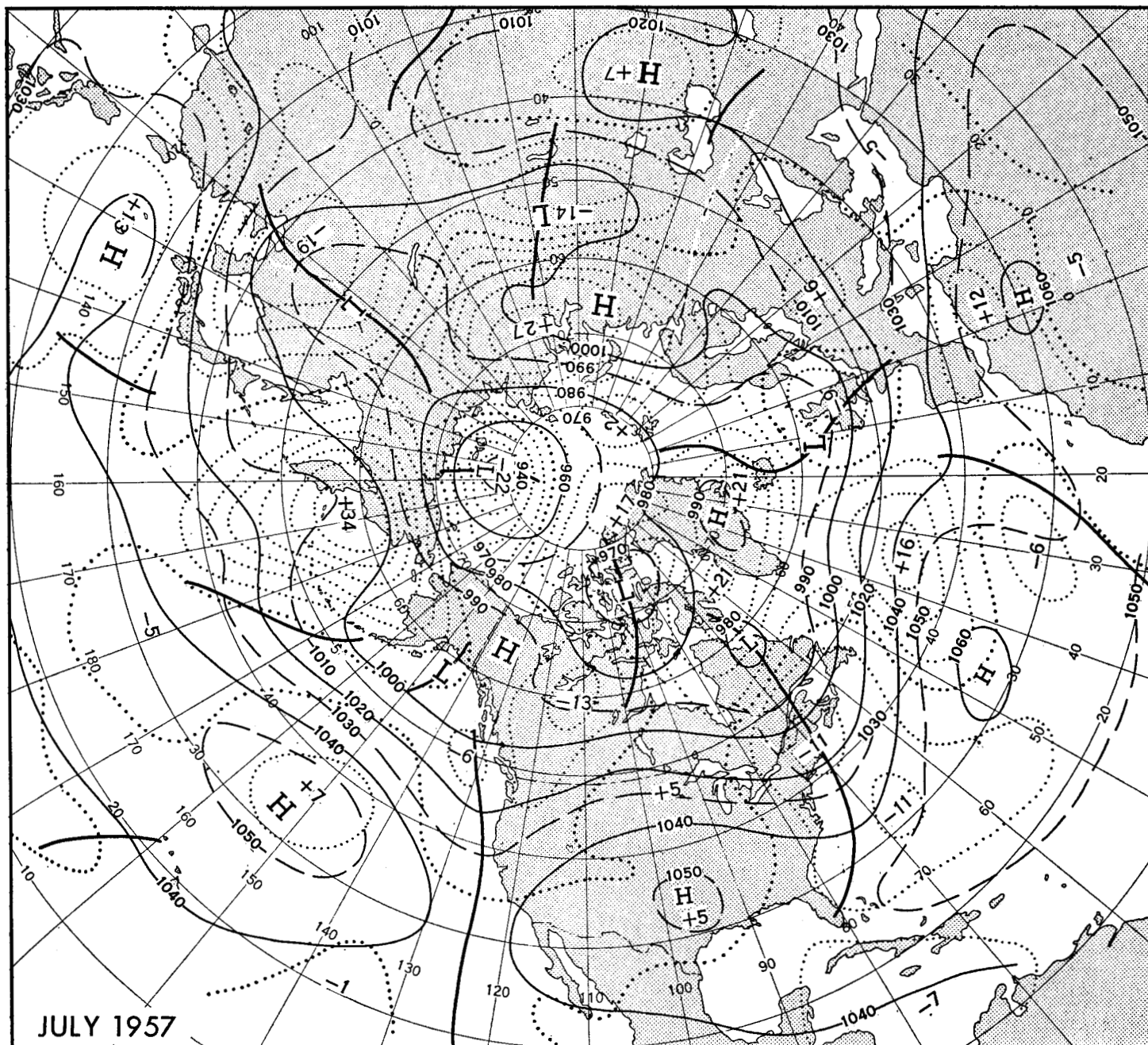


FIGURE 2.—Mean 700-mb. contours (solid) and height departures from monthly normal (dotted) (both in tens of feet) for July 1957, with troughs indicated by heavy vertical lines. Note complete change in phase from June (fig. 1).

complete circumpolar ring. The only other conspicuous high latitude feature was the strong, persistent, closed polar Low around 75° N. latitude and 160° E. longitude. The Icelandic Low (or Lows), although still present, was considerably weakened by the blocking.

An aspect of no little importance was the stability of the major westerly wave train. This was most noteworthy in the United States where successive 5-day mean maps reveal only minor shifts in the long wave pattern throughout the month. Variations in depth of the coastal troughs, minor fluctuations in their position, and changes in the upper level anticyclone over central United States

constituted the major 5-day circulation features. More sizable alterations were noted in Canada where the direct effects of blocking surges were stronger and more apparent.

The 200-mb. circulation features, figure 4, were essentially similar to the 700-mb. pattern except for the disappearance of the Greenland anticyclone at higher levels. As usual, the summer maritime troughs were better defined aloft, but the westerly waves retained the same relation and identity. Both Arctic and temperate mean jets were present with a clear westerly maximum just about girdling the globe between 40° and 50° N. The mean jet over the United States also demonstrated the phase change from June [1] noted in other circulation features.

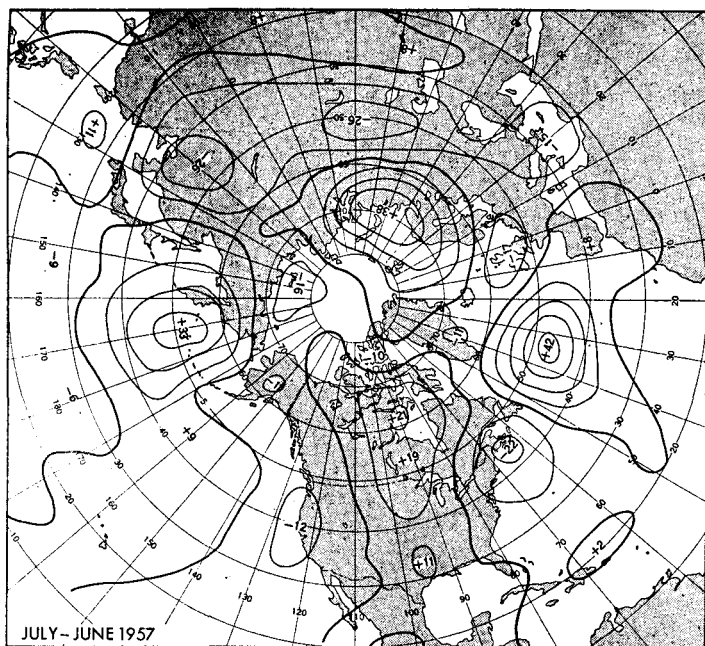


FIGURE 3.—Changes in monthly mean 700-mb. height departures from normal—June to July 1957. The lines of equal anomalous height change are drawn at 100-foot intervals with the centers labeled in tens of feet. Rises in central United States were accompanied by falls along each coast.

2. WEATHER OF THE MONTH

Mean temperatures for July, Chart I-B, were 1° to 4° F. above normal from Texas to North Dakota in central United States where, under the upper-level High and the generally anticyclonic circulation, there was sufficient insolation and warm air advection. To both the east and west the coastal troughs were effective in producing cooler regimes. Stronger than normal maritime influences were operative in the Northwest, while the Southwest was cooled in part by the cloudiness attending shower activity in the western moist tongue. Coastal California was warm, although well inland it was cool—a condition commonly attributed to a weakening of the sea-breeze regime.

Temperatures over eastern United States were interesting in that near to below normal temperatures did occur as usual to the rear of the coastal trough, but a coastal strip from the Outer Banks of North Carolina to New Hampshire remained above normal. Considering the depth of the offshore trough, this warmth appears rather difficult to rationalize, especially since the thicknesses from 1000 to 700 mb. (not shown) were definitely below (mean virtual temperatures cooler than) normal over the entire area. However, temperatures in interior regions of the East averaged only 1° to 2° F. below normal at the surface, and even these departures seemed intimately associated with precipitation (Chart II) and the cloudiness associated with it (Chart VI). Thus, for the most part, air only slightly cooler than normal at lower levels was advected over the coastal strip and, in the descent from the Appalachians, was heated enough to account for the coastal

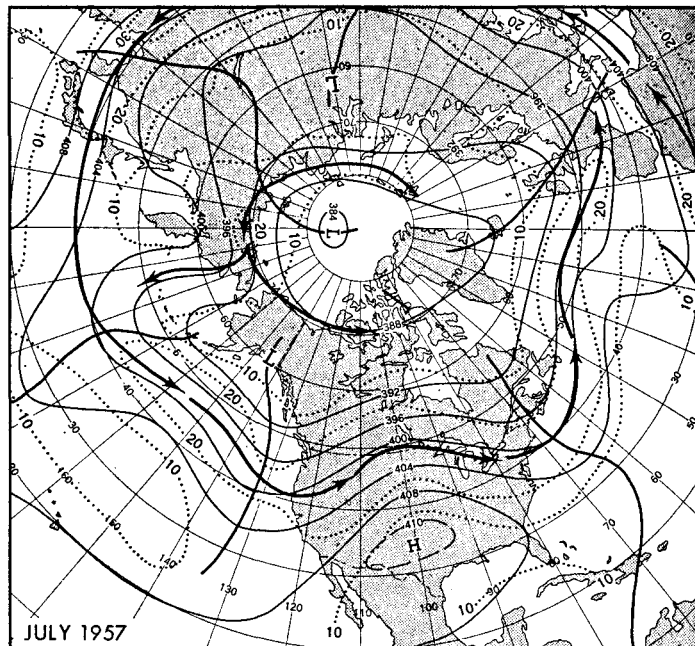


FIGURE 4.—Mean 200-mb. contours (solid, in hundreds of feet) and isotachs (dotted, in meters per second) for July 1957. Solid arrows indicate the position of the 200-mb. mean jet stream, which was displaced northward and curved sharply anticyclonically around strong mean High in central United States.

warmth. Further warming was produced by abundant sunshine (Chart VII) in an area where little rainfall was recorded.

Precipitation (Charts II and III) was reasonably plentiful in many parts of the country. On the northwest coast it was caused by forced ascent of cool moist maritime air and frontal activity. In a wide band from New Mexico and eastern Arizona northward through the western Plains and eastward through the Great Lakes to New England, showers in the western moist tongue spread northward and then eastward. Some of the moisture also eddied anticyclonically over the central Mississippi Valley where as much as twice the normal amount of precipitation was recorded. In the Southeast heavy rains were associated with quasi-stationary frontal activity and the instability induced by the attending cyclonic circulation. Less than ½ inch of rain was recorded over a wide belt of the Far West lying between the rains on the southern edge of the westerlies in the extreme Northwest and the continental summer showers in the Southwest and central Rockies. It was also a period of drying-out in Texas and Oklahoma, where little flow of Gulf moisture and no perturbations of consequence were noted. The only other dry area of significance occurred in the East behind the mean trough off the East Coast.

In the preceding discussion of circulation changes the obvious reversal in flow characteristics from June to July was highlighted to some extent. It would seem appropriate therefore also to indicate the accompanying changes in temperature and precipitation. The monthly changes in temperature by class are shown in figure 5A. (For

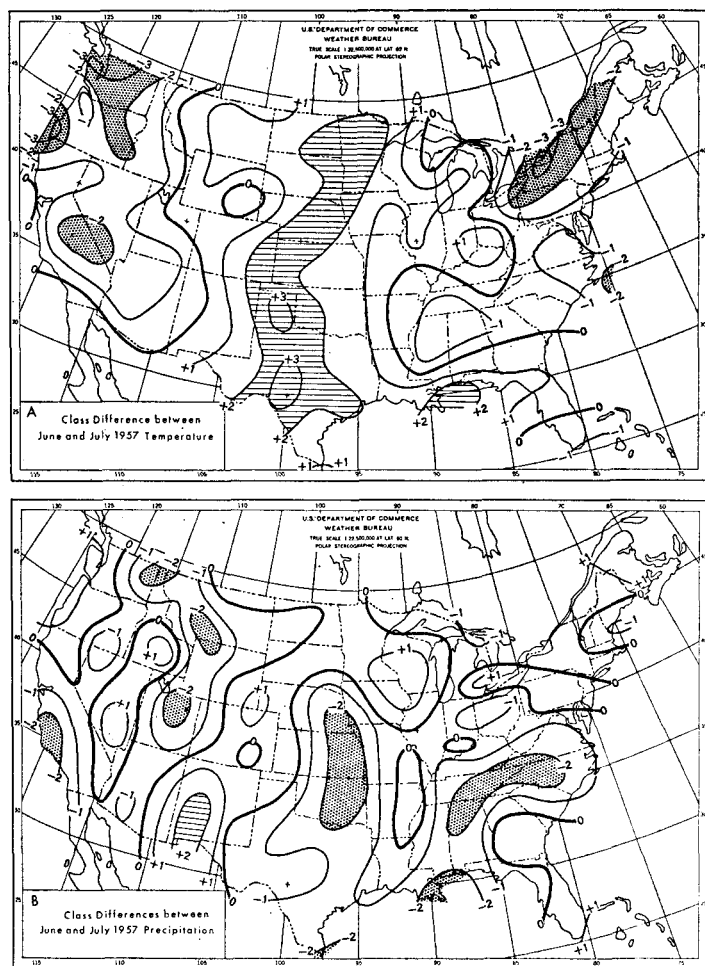


FIGURE 5.—Number of classes the anomaly of temperature (A) and precipitation (B) changed from June to July 1957, with increased values considered positive and decreased values negative. Areas with increases of two or more classes are cross-hatched; areas with decreases of two or more classes are dotted.

definition of classes, see reference [7].) Temperatures fell one to three classes in the Far West (except coastal California) due to increased trough activity in the north and cloudiness in the south. Temperatures rose two to three classes from Texas to Minnesota as heights rose and the ridge of July replaced the trough of June. Along the east coast cooling was generally in order as the trough deepened offshore.

Precipitation changes, also by class, are indicated in figure 5B. Drying occurred under the upper-level High in central United States and also over most of the East to the rear of the trough, except the Southeast which remained wet, and the eastern drought area which remained dry. The continental showers of summer produced wetter conditions from New Mexico north-northeastward as well as in eastern Nevada and Idaho. Most of California received no rain at all as the westerlies shifted northward and typically arid summer weather was established. However, in northern California westerly trough activity caused an increase in coastal precipitation.

TABLE 1.—Total precipitation (inches) and its departure from normal in eastern drought area.¹

Station	April 8 to August 18 period				
	1957		Record minimum for previous 50 years		
	Total	Dep.	Total	Dep.	Year
Boston, Mass.	7.89	-6.10	6.94	-7.05	1950
Nantucket, Mass.	8.03	-5.54	5.71	-7.86	1949
Providence, R. I.	5.65	-8.17	8.69	-5.13	1914
Bridgeport, Conn.	7.83	-8.47	8.07	-8.23	1911
New York, N. Y.	9.12	-7.30	6.91	-9.51	1939
Philadelphia, Pa.	5.81	-11.23	10.80	-6.23	1923
Harrisburg, Pa.	7.23	-8.07	9.16	-6.14	1939
Baltimore, Md.	6.67	-10.18	7.54	-9.31	1930
Washington, D. C.	6.52	-10.19	8.11	-8.60	1930
Norfolk, Va.	11.89	-7.27	10.44	-8.72	1944
Richmond, Va.	11.68	-6.97	8.62	-10.03	1911

¹ From *Weekly Weather and Crop Bulletin, National Summary*, vol. XLIV, No. 33, U. S. Weather Bureau, Washington, D. C., Aug. 19, 1957.

3. EASTERN DROUGHT

Certainly one of the major items of topical interest was the intense drought which gripped parts of the East. From North Carolina to southern New England the coastal areas received only 25 to 50 percent of normal July precipitation. The lack of rainfall could be directly associated with the offshore trough and the dry northerly and northwesterly components of flow which prevailed at most levels. The upper-level continental anticyclone appeared to be too weak to carry the moisture on the rear side up and across central United States far enough to be effective in the East.

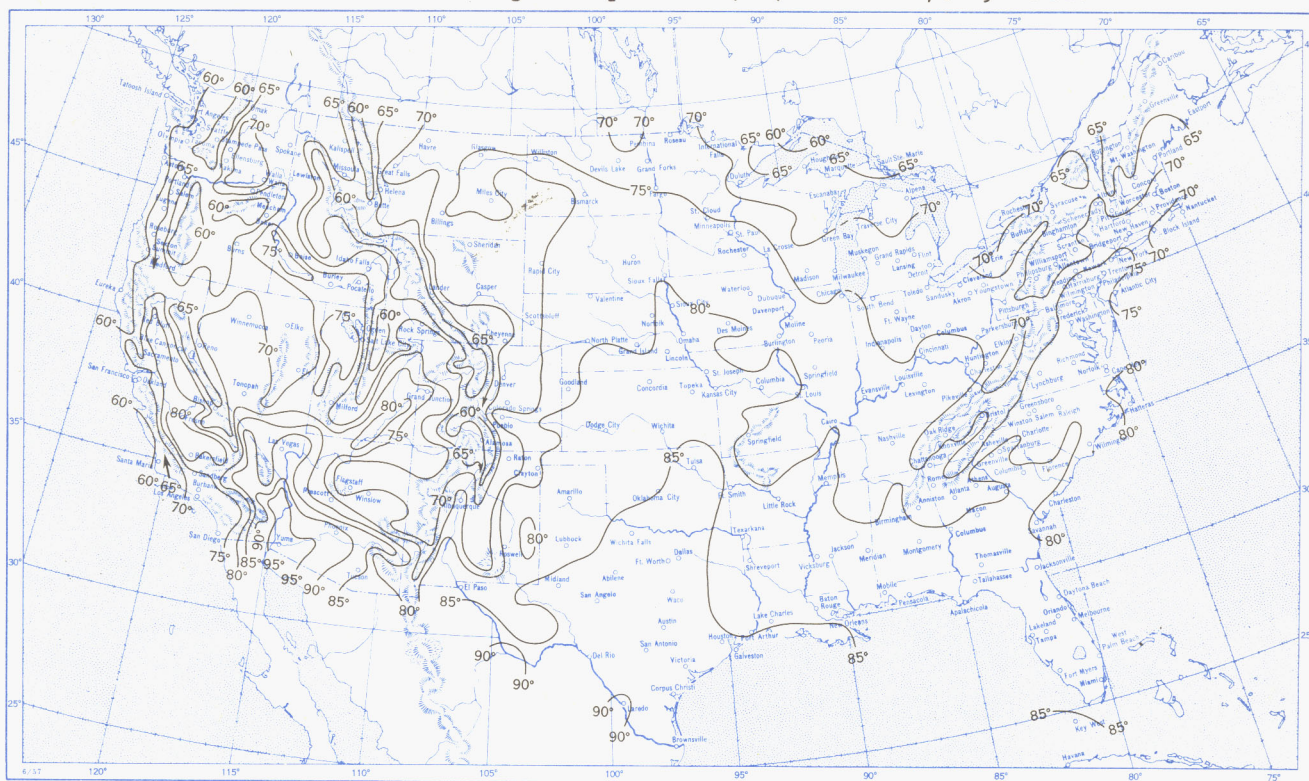
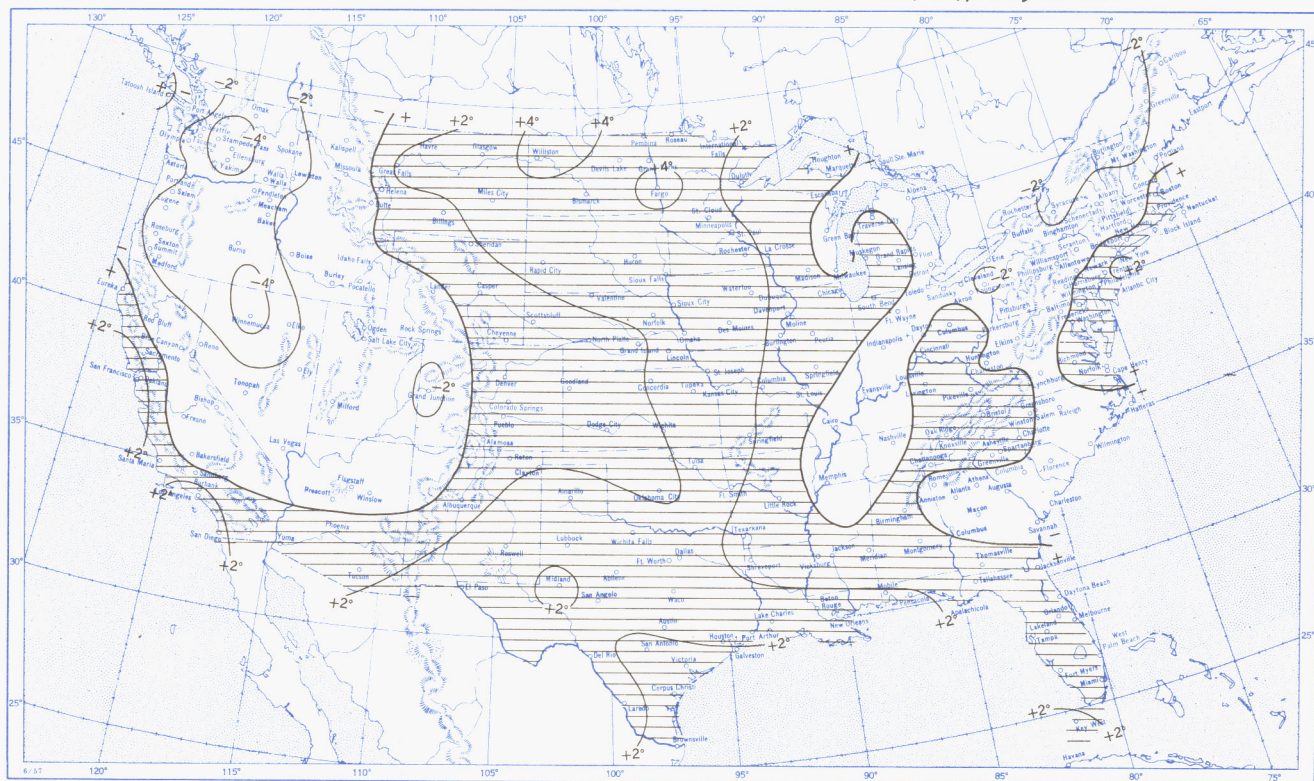
In June, when the circulation was reversed, the central United States trough was apparently too far west for significant precipitation in the East [1]. A similar condition prevailed during April and May. The transition from one regime to the other was sharp and rapid with little opportunity for effective relief. As a result, much of the East, which had enjoyed a satisfactory ground moisture condition in early spring, was suffering a very severe drought. In duration, this could not compare to many quite recent occurrences in the central and southern Plains, but in severity the eastern drought was quite noteworthy. Numerous July minimum precipitation records were set, but of greater significance is table 1 which compares the indicated 19-week precipitation totals with record minima for the previous 50 years at 11 selected eastern drought stations. Thus one sees that at Providence, R. I.; Bridgeport, Conn.; Philadelphia, Pa.; Harrisburg, Pa.; Baltimore, Md.; and Washington, D. C., this has been the driest growing season in 50 years.

The riddle of basic causation as related to a phenomenon such as the eastern drought still lies beyond the scope of present meteorological theory. Although certain aspects of atmospheric behavior are better understood and better explained than ever before, the role of instantaneous interactions within the mean ensemble is just beginning to be appreciated and analytically investigated. As of now, one can only point out that the very stable pattern of July—

strong trough off the east coast and small upper-level anticyclone over central United States—was sufficient to maintain extreme drought along the coastal strip. The cyclonic activity associated with the trough was too far east, and the High was too weak and/or too far west to transport adequate moisture into the East. How much the preceding dryness (April–June) contributes to such a regime may be evaluated in the not far distant future. But, given such knowledge, the essential problem is still only once removed. There remains basically a problem in understanding which will never be satisfied with the old saying: “All signs fail in time of drought.”

REFERENCES

1. W. H. Klein, “The Weather and Circulation of June 1957—Including an Analysis of Hurricane Audrey in Relation to the Mean Circulation,” *Monthly Weather Review*, vol. 85, No. 6, June 1957, pp. 208–220.
2. C. M. Woffinden, “The Weather and Circulation of February 1957—Another February with a Pronounced Index Cycle and Temperature Reversal over the United States,” *Monthly Weather Review*, vol. 85, No. 2, Feb. 1957, pp. 53–61.
3. C. R. Dunn, “The Weather and Circulation of November 1956—Another October to November Circulation Reversal,” *Monthly Weather Review*, vol. 84, No. 11, Nov. 1956, pp. 391–400.
4. W. H. Klein, “The Weather and Circulation of May 1956—Another April–May Reversal,” *Monthly Weather Review*, vol. 84, No. 5, May 1956, pp. 190–197.
5. J. F. Andrews, “The Weather and Circulation of July 1955—A Prolonged Heat Wave Effected by a Sharp Reversal in Circulation,” *Monthly Weather Review*, vol. 83, No. 7, July 1955, pp. 147–153.
6. W. H. Klein, “The Weather and Circulation of May 1954—A Circulation Reversal Effected by a Retrogressive Anticyclone During an Index Cycle,” *Monthly Weather Review*, vol. 82, No. 5, May 1954, pp. 123–130.
7. J. Namias, “The Annual Course of Month-to-Month Persistence in Climatic Anomalies,” *Bulletin of the American Meteorological Society*, vol. 33, No. 7, Sept. 1952, pp. 279–285.

Chart I. A. Average Temperature ($^{\circ}\text{F.}$) at Surface, July 1957.B. Departure of Average Temperature from Normal ($^{\circ}\text{F.}$), July 1957.

A. Based on reports from over 900 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.

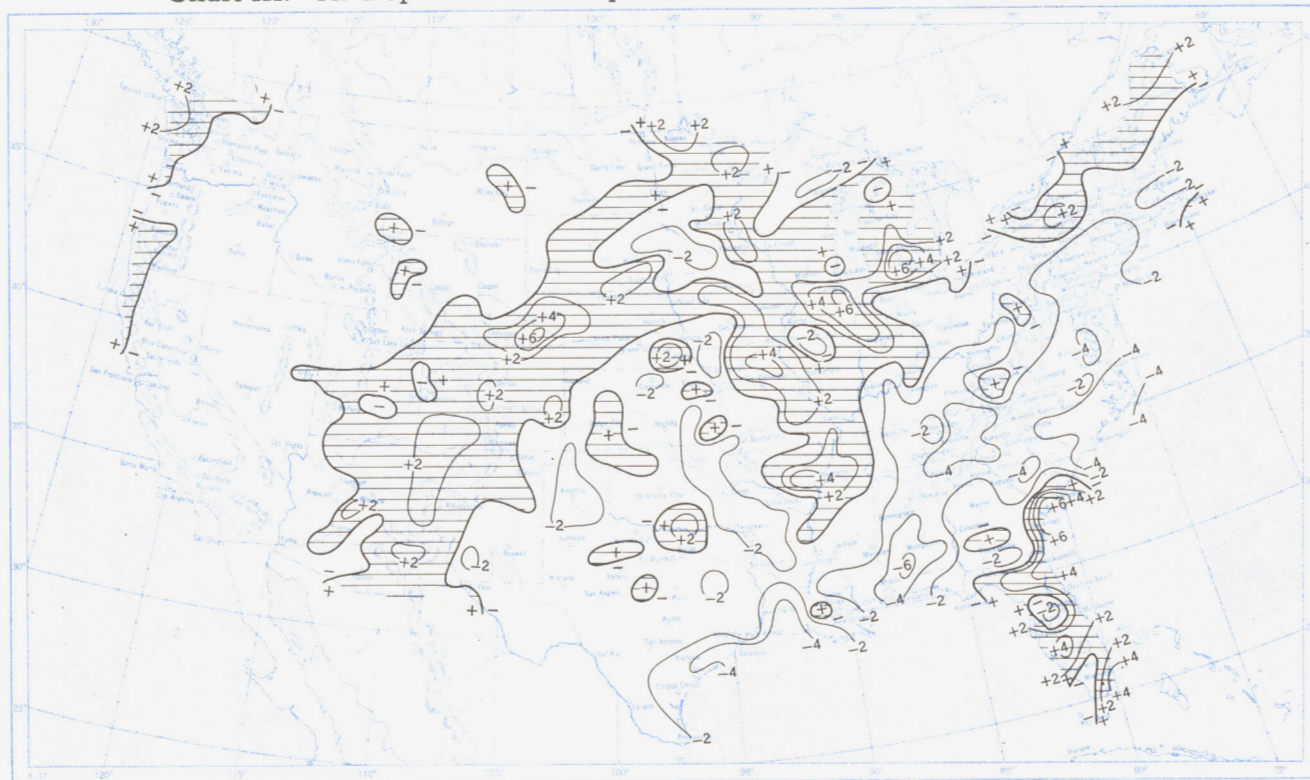
B. Departures from normal are based on the 30-yr. normals (1921-50) for Weather Bureau stations and on means of 25 years or more (mostly 1931-55) for cooperative stations.

Chart II. Total Precipitation (Inches), July 1957.

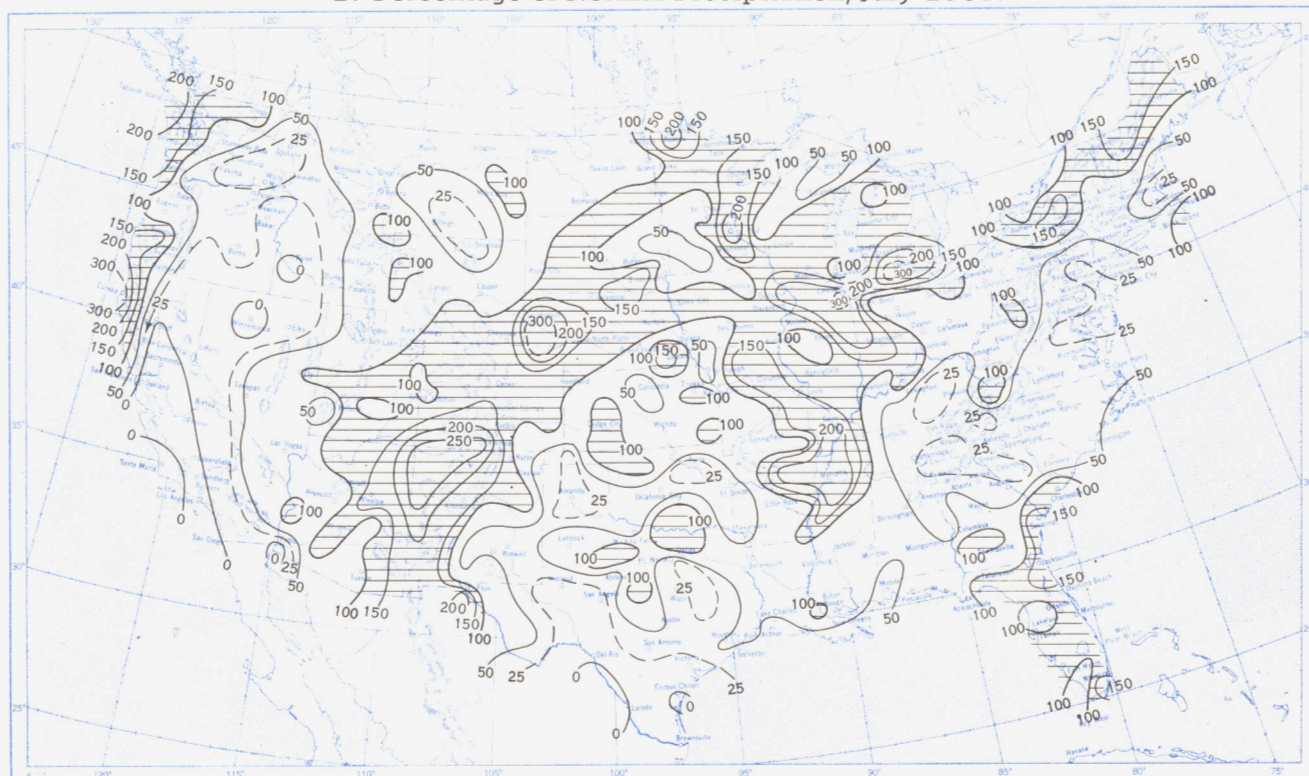


Based on daily precipitation records at about 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), July 1957.

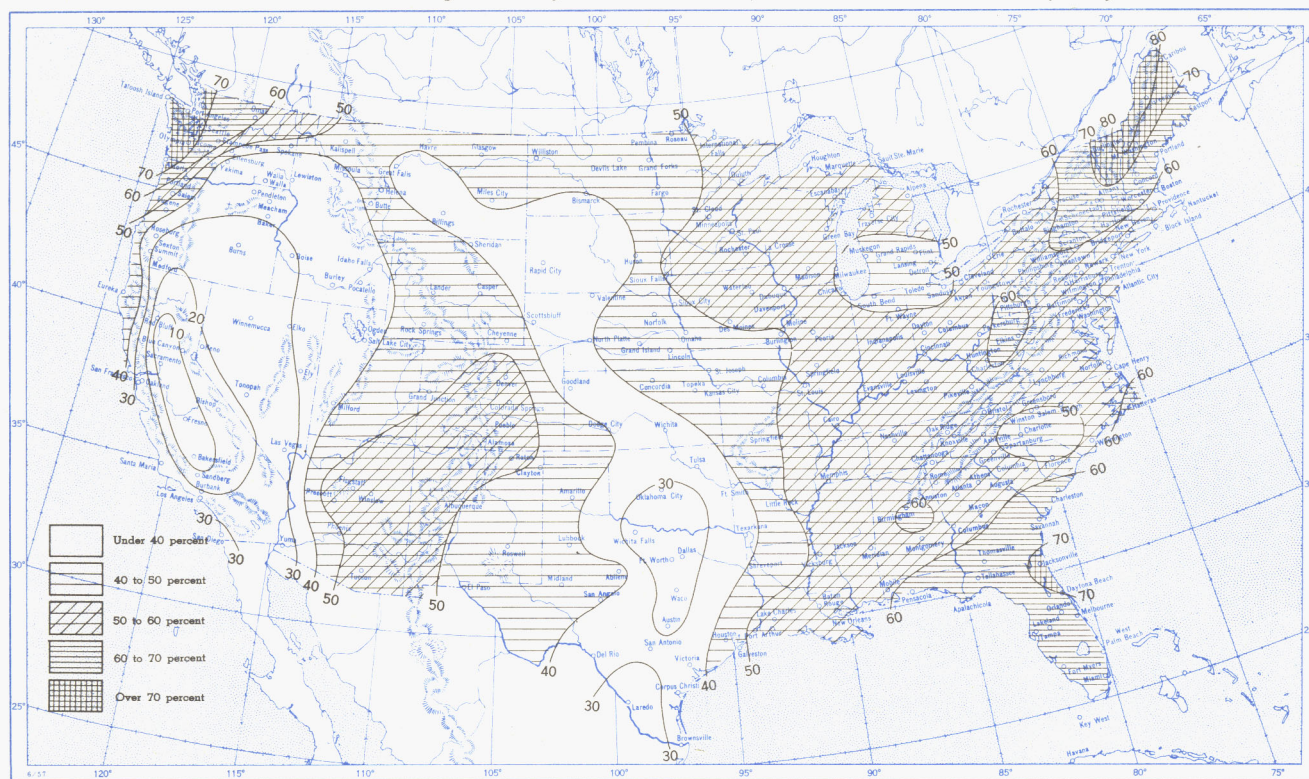


B. Percentage of Normal Precipitation, July 1957.

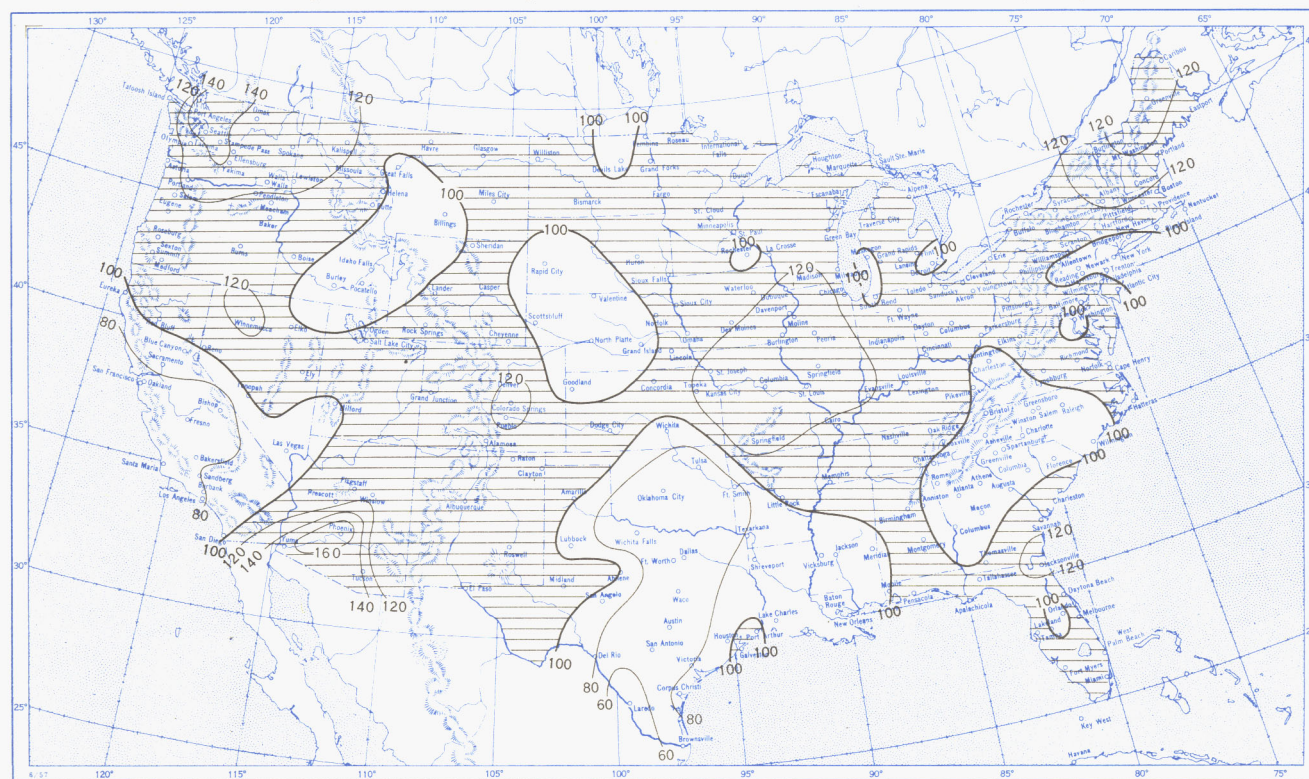


Normal monthly precipitation amounts are computed from the records for 1921-50 for Weather Bureau stations and from records of 25 years or more (mostly 1931-55) for cooperative stations.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, July 1957.



B. Percentage of Normal Sky Cover Between Sunrise and Sunset, July 1957.

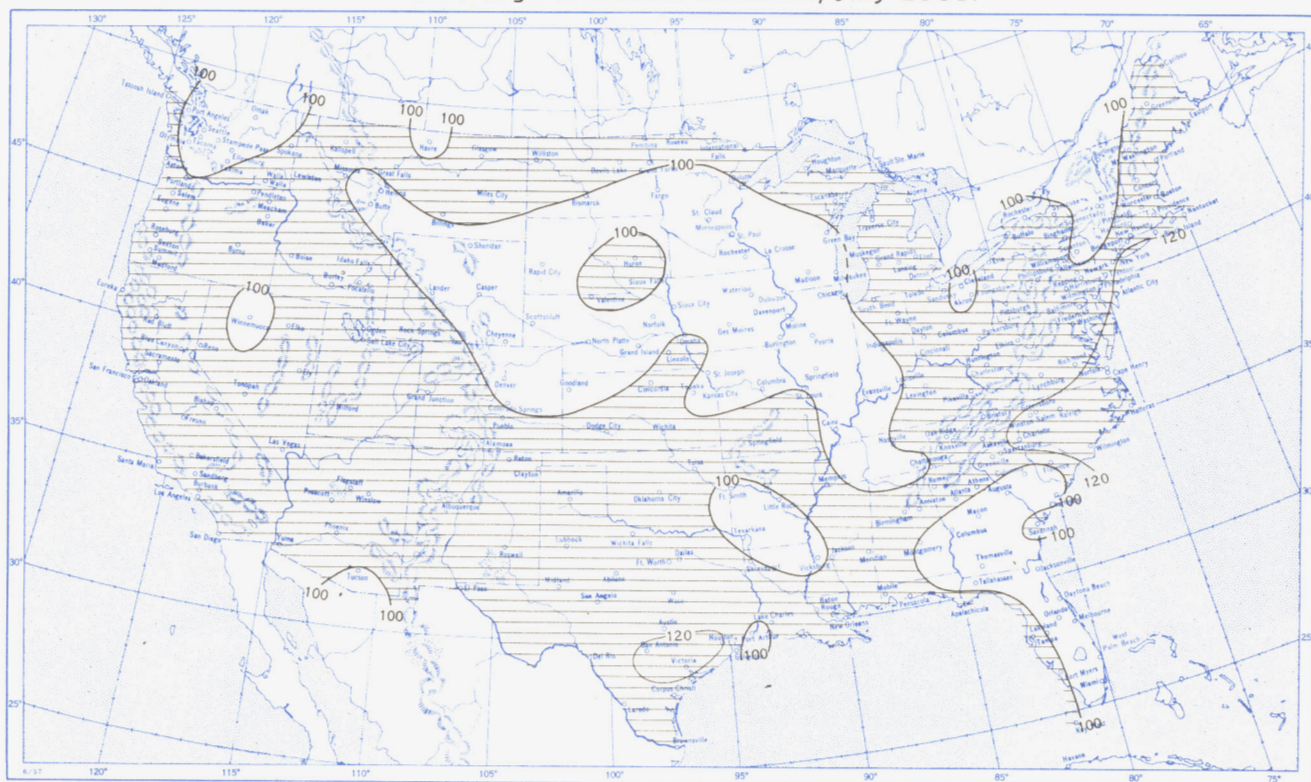


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, July 1957.



B. Percentage of Normal Sunshine, July 1957.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, July 1957. Inset: Percentage of Mean Daily Solar Radiation, July 1957. (Mean based on period 1951-55.)

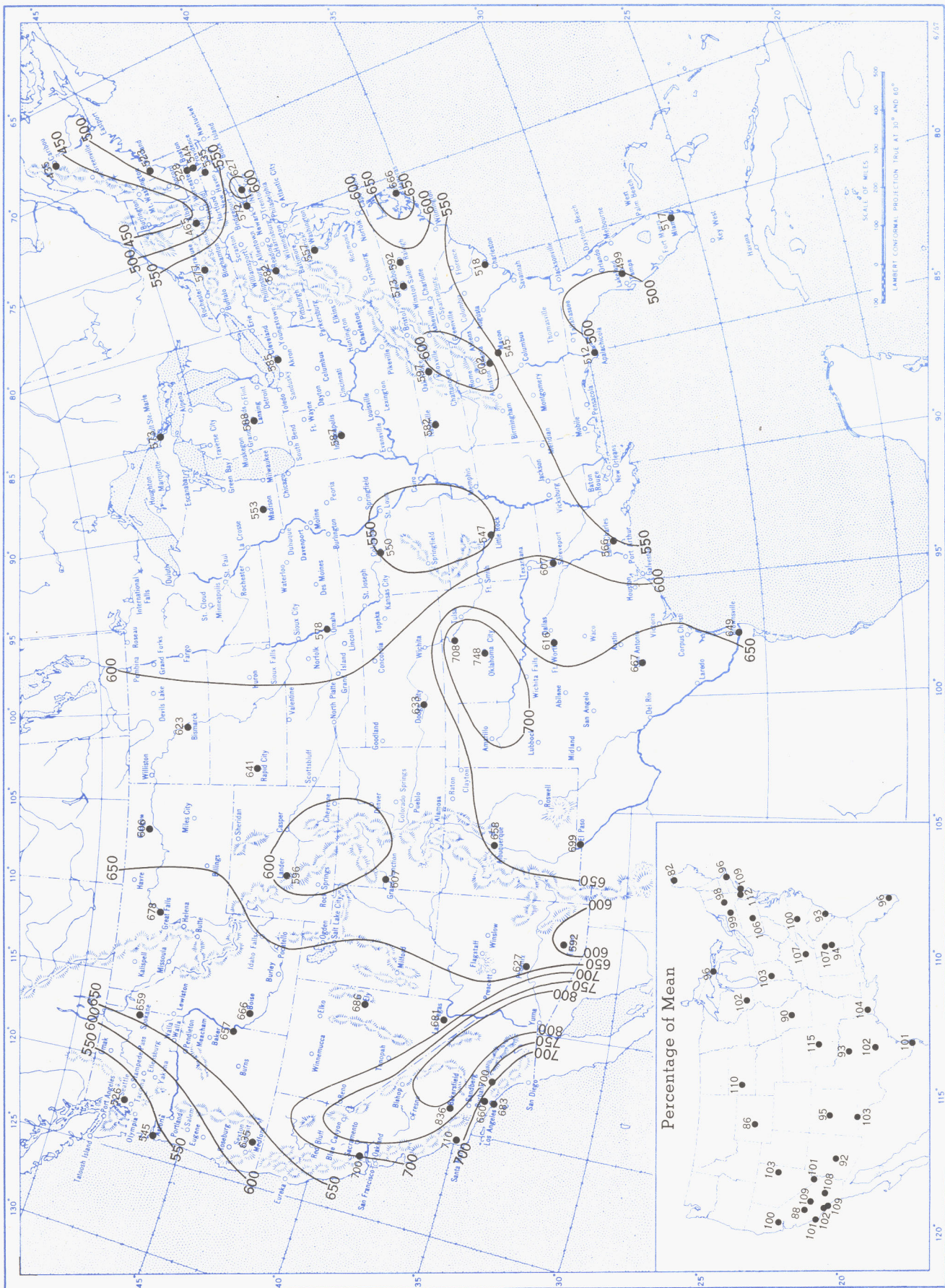
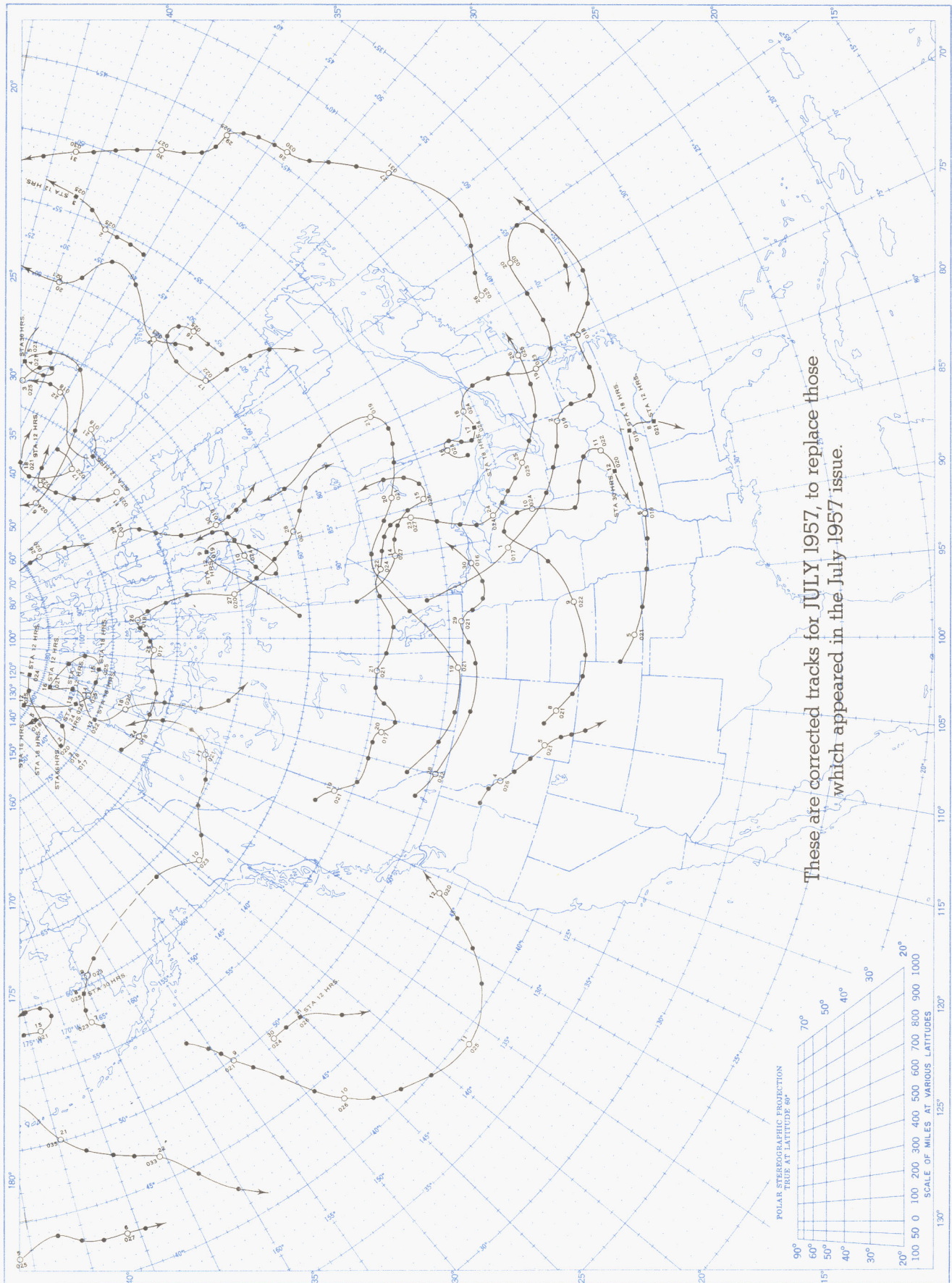


Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm.⁻²). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. The inset shows the percentage of the mean based on the period 1951-55.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, July 1957.



Circle indicates position of center at 7:00 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, July 1957.

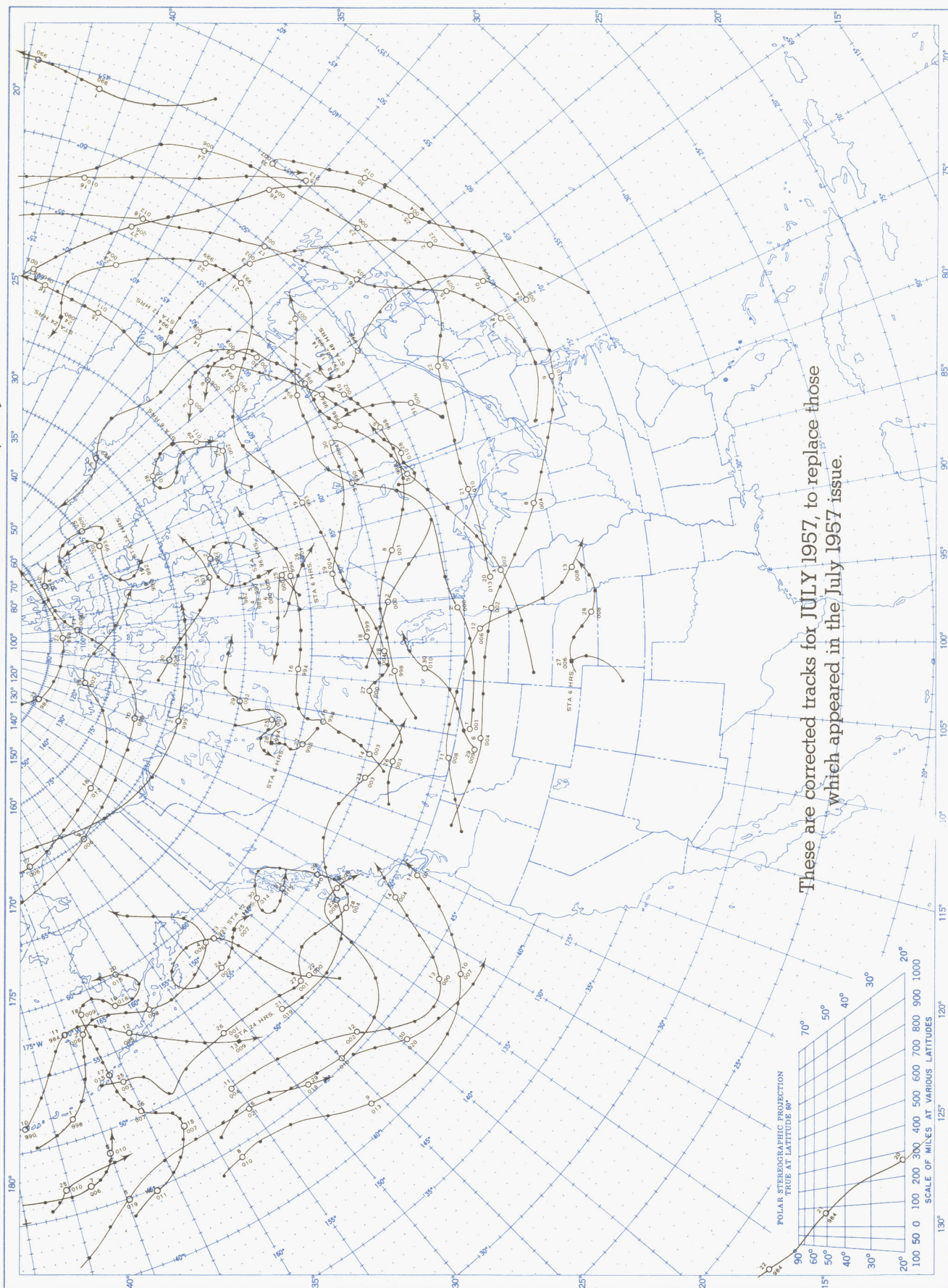
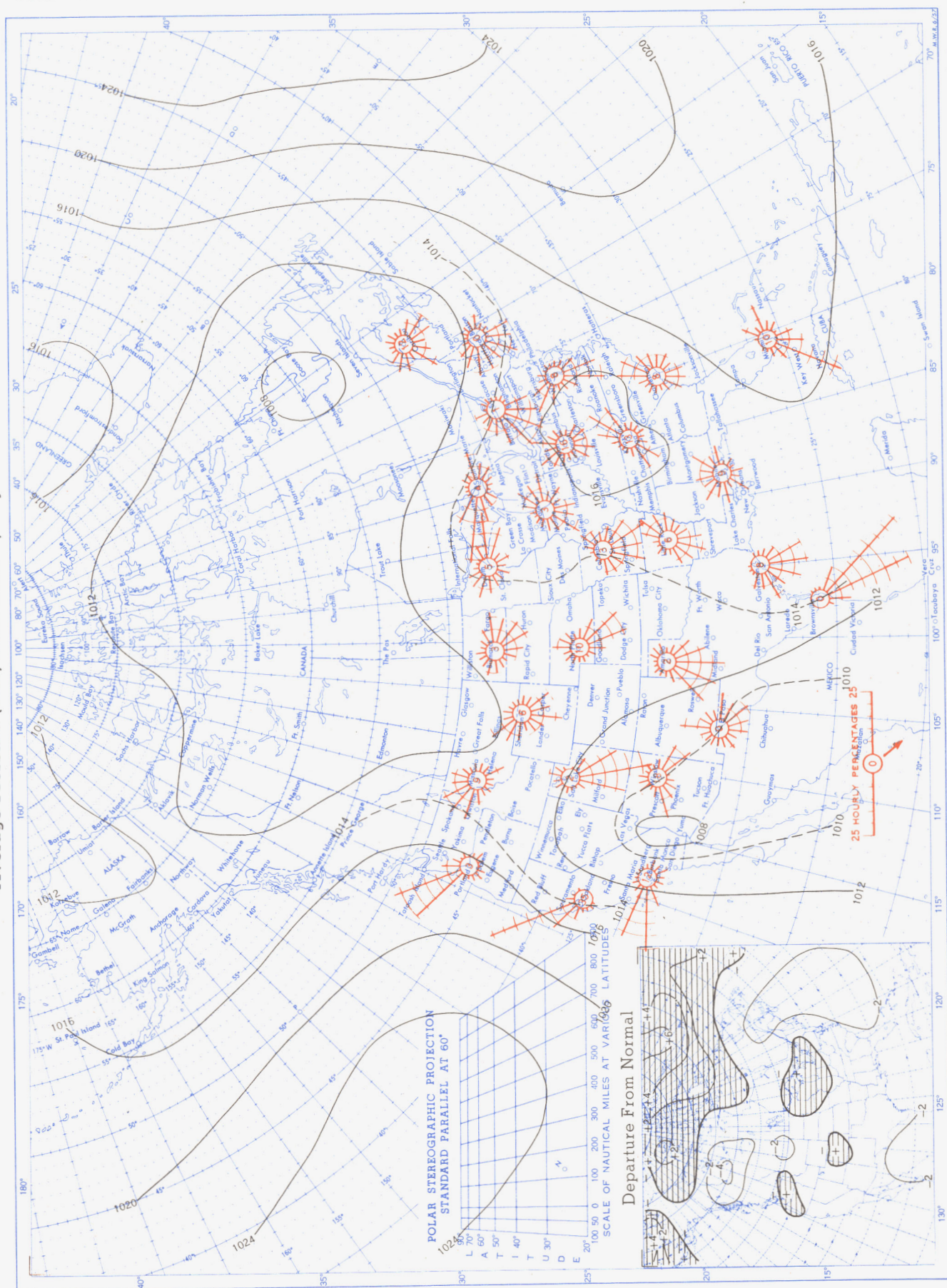


Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, July 1957. Inset: Departure of Average Pressure (mb.) from Normal, July 1957.



Average sea level pressures are obtained from the averages of the 7:00 a. m. and 7:00 p. m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° inter-sections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. 850-mb. Surface, 1200 GMT, July 1957. Average Height and Temperature, and Resultant Winds.

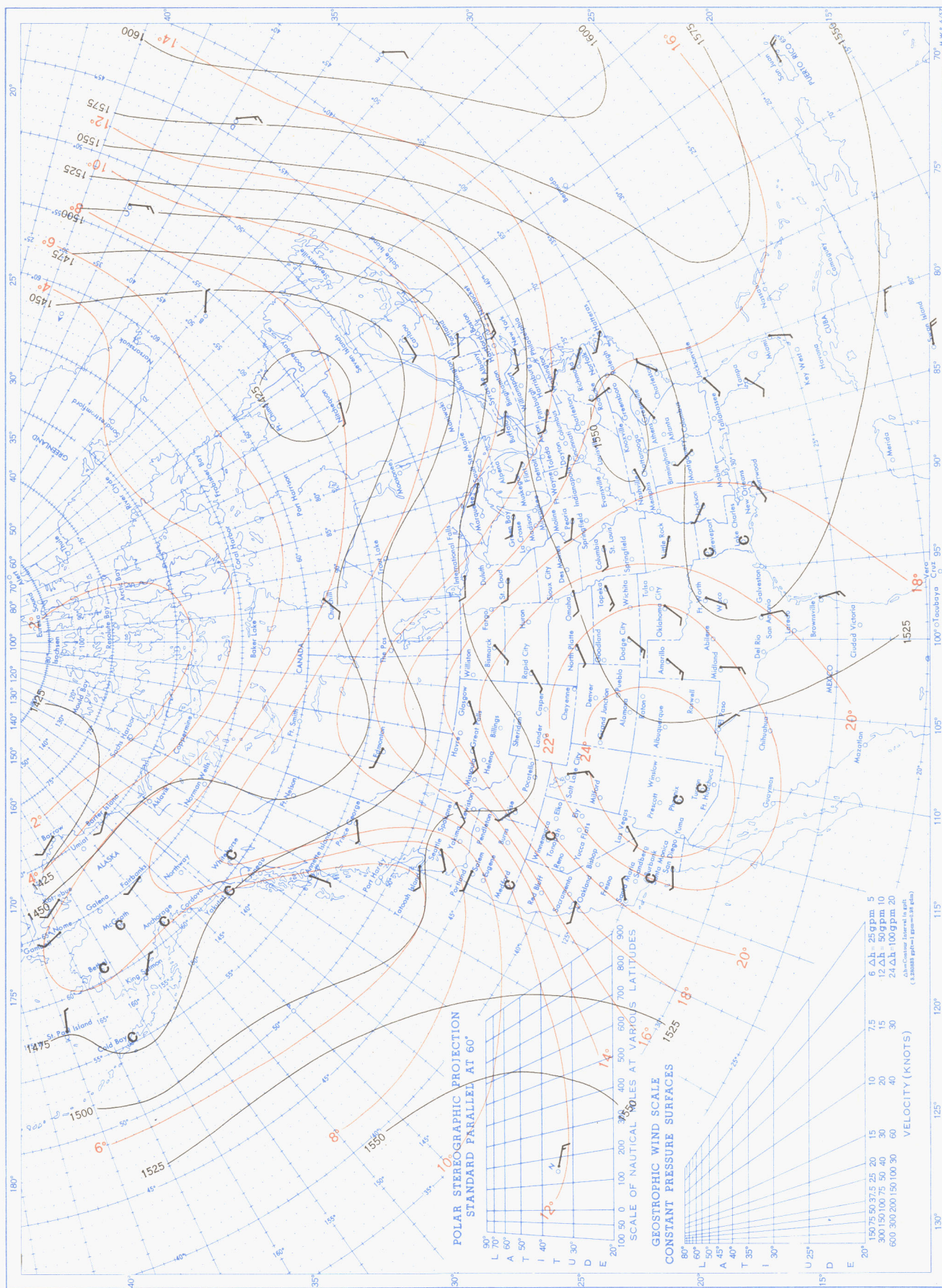
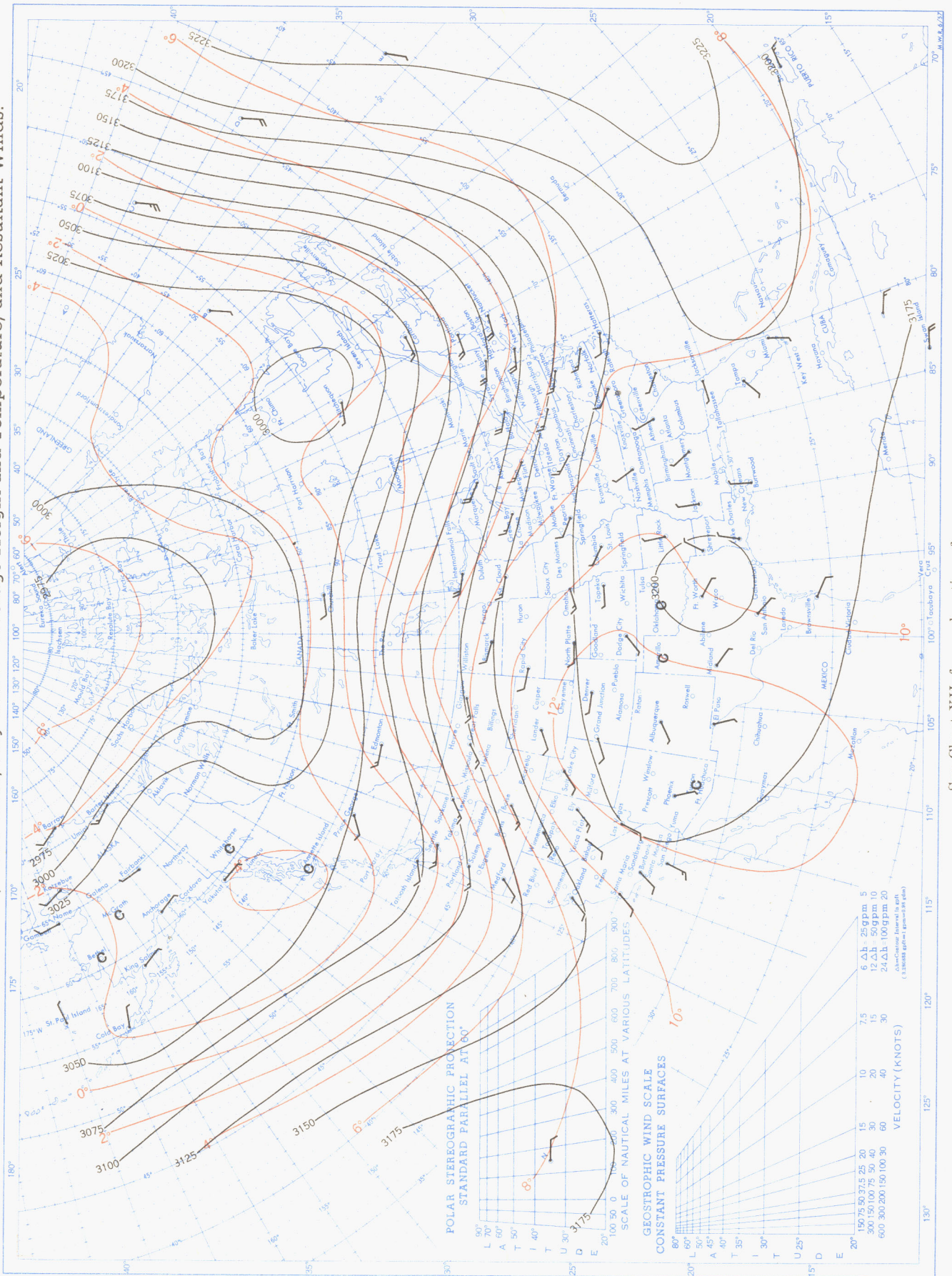
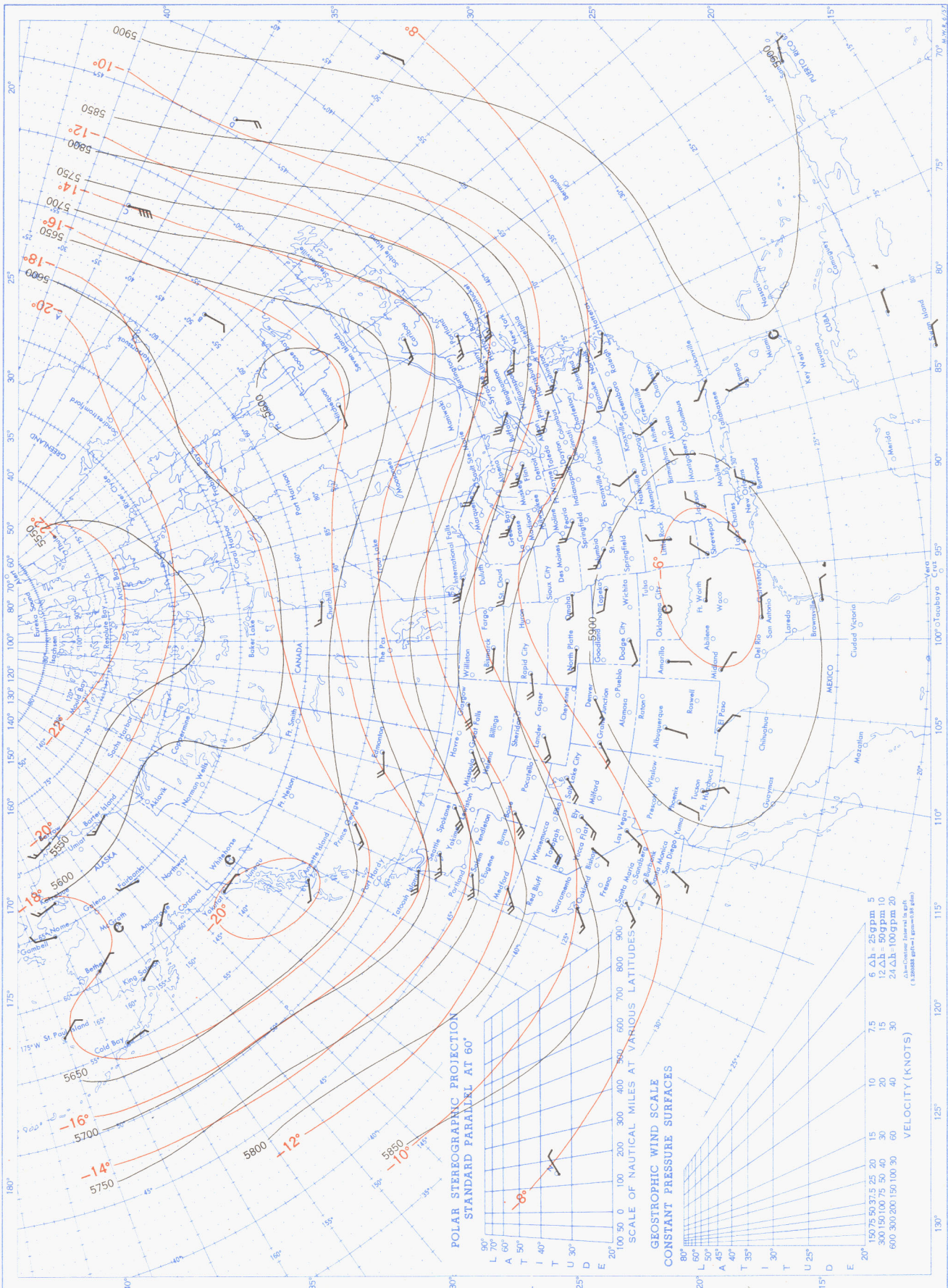


Chart XIII. 700-mb. Surface, 1200 GMT, July 1957. Average Height and Temperature, and Resultant Winds.



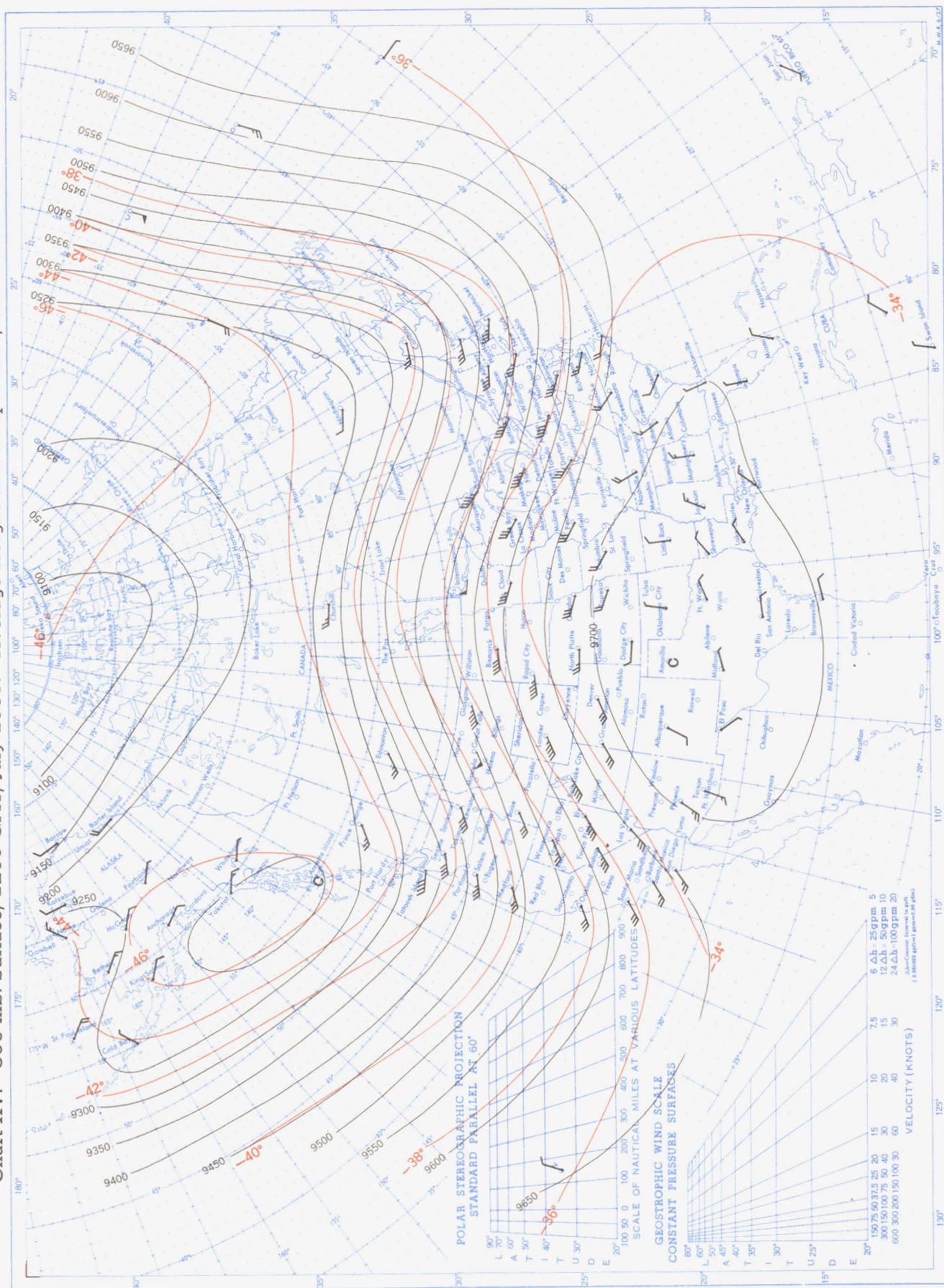
See Chart XII for explanation of map.

Chart XIV. 500-mb. Surface, 1200 GMT, July 1957. Average Height and Temperature, and Resultant Winds.



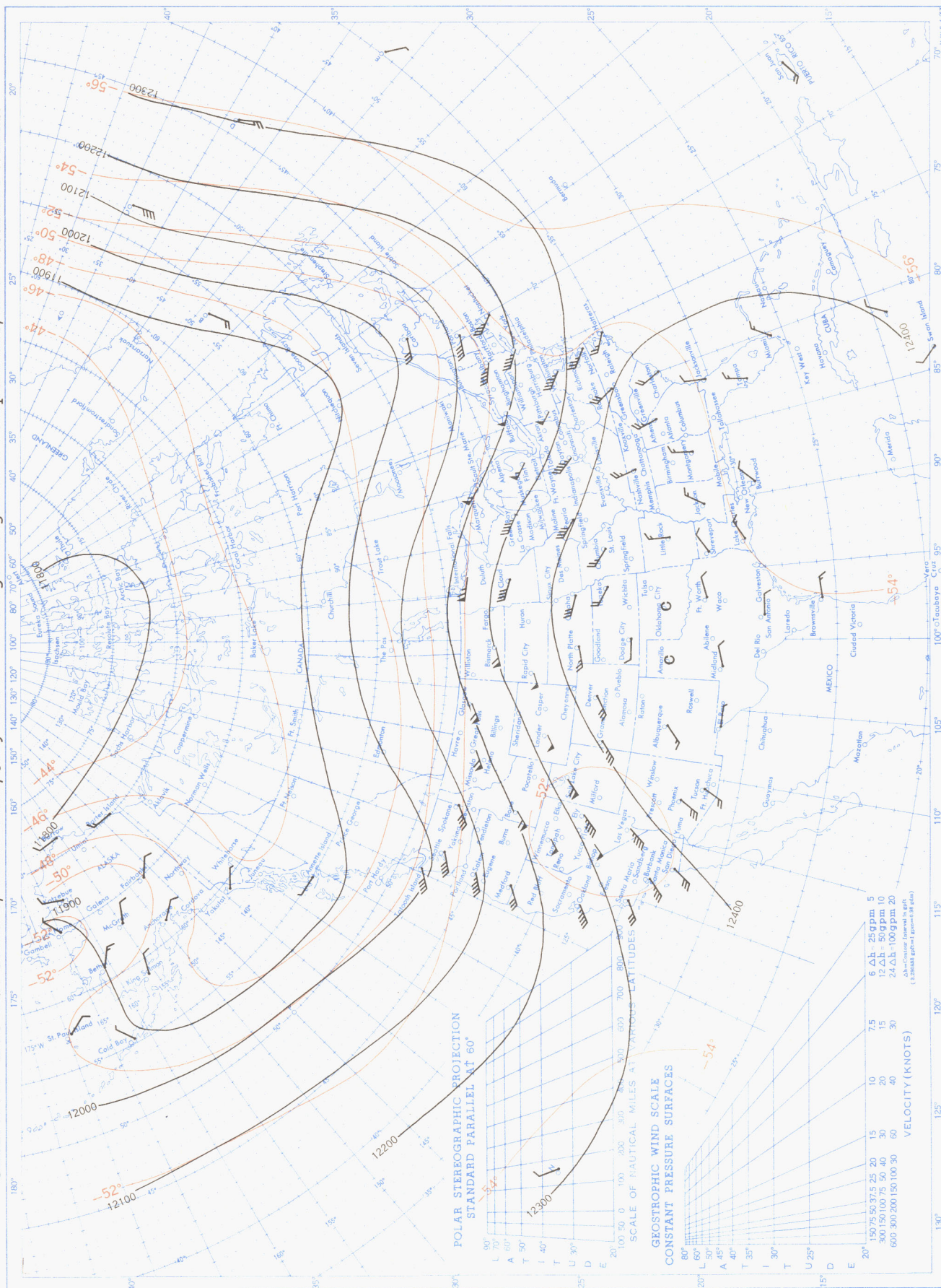
See Chart XII for explanation of map.

Chart XV. 300-mb. Surface, 1200 GMT, July 1957. Average Height and Temperature, and Resultant Winds.



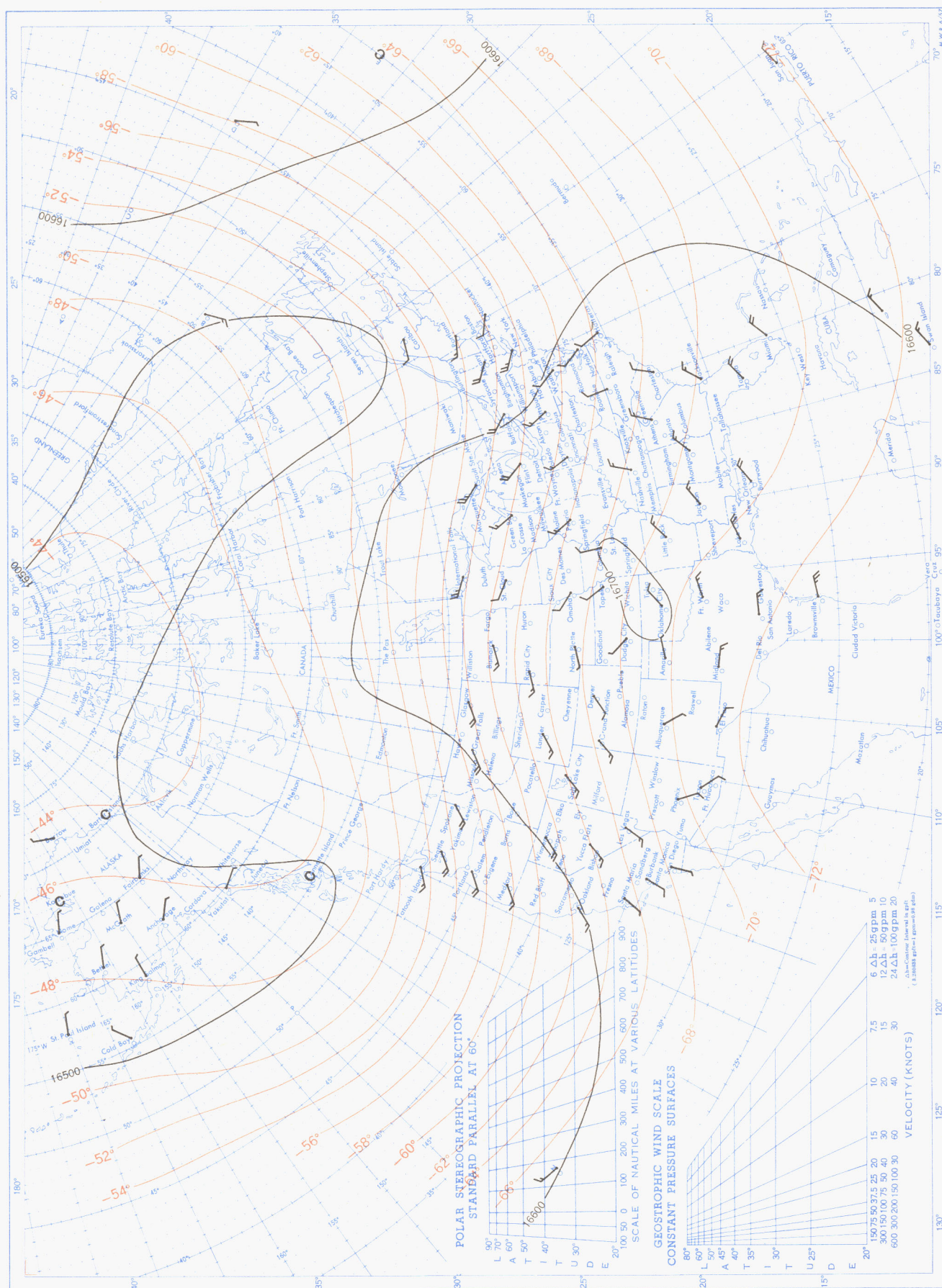
See Chart XII for explanation of map.

Chart XVI. 200-mb. Surface, 1200 GMT, July 1957. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map.

Chart XVII. 100-mb. Surface, 1200 GMT, July 1957. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map.